and blends, including reactor blends, of amorphous polypropylene, isotactic polypropylene, and metallocene catalyzed polypropylenes. These thermoplastic polymers may have a molecular weight distribution that is in the range of from about 2.0 to about 20.0, desirably from about 2.0 to about 12.0, even more desirably from about 2.0 to about 8.0.

The thermoplastic polymers compositions of this invention may have a weight average molecular weight (M_w) that is in the range of from about 60,000 to about 750,000, and desirably from about 100,000 to about 500,000, and most desirably from about 150,000 to about 400,000. These thermoplastic polymer compositions may have a melt flow rate (MFR) that is in the range of from about 0.2 dg/min to about 30 dg/min, desirably from about 0.5 dg/min to about 20.0 dg/min, even more desirably from about 1.0 dg/min to about 10.0 dg/min. The melting point of the thermoplastic polymer may be less than about 162°C, desirably less than about 155°C, and most desirably less than about 150°C. Upper limits for melting point depend on the specific application but would typically not be higher than 170°C. The hexane extractables level (as measured by 21 CFR 177.1520(d)(3)(i)) of the these thermoplastic polymers may be less than 2.0 wt%, and desirably less than 1.0 wt%.

The thermoplastic polymers of this invention can be blended with other polymers, particularly with other polyolefins. Specific examples of thermoplastic polymers include, but are not limited to ethylene-propylene rubber, ethylene-propylene diene rubber, and ethylene plastomers. Specific examples of commercially available ethylene plastomers include EXACT™ resins products of Exxon Chemical Company and, AFFINITY™ resins and ENGAGE™ resins, products of Dow Chemical Company.

Thermoplastic Polypropylene Modifier

Thermoplastic polypropylene modifiers may be those commonly employed with plastics. Examples include one or more of the following: heat stabilizers or antioxidants, neutralizers, slip agents, antiblock agents, pigments, antifogging agents, antistatic agents, clarifiers, nucleating agents, ultraviolet absorbers or light stabilizers, fillers, hydrocarbon resins, rosins or rosin esters, waxes, additional plasticizers and other additives in conventional amounts.

Effective levels are known in the art and depend on the details of the base polymers, the fabrication mode and the end application. In addition, hydrogenated and/or petroleum hydrocarbon resins and other plasticizers may be used as modifiers.

The plasticized polypropylene thermoplastic composition may include from 0 to 20 wt% of a thermoplastic polypropylene modifier compound other than the ethylene copolymer. Desirably, the thermoplastic polypropylene modifier constitutes greater than 0.001 wt% of the plasticized polypropylene thermoplastic composition.

Metallocene Catalyzed Thermoplastic Polymers

The preparation of metallocene catalyzed thermoplastics and particularly metallocene catalyzed polypropylene involves the use of metallocene catalyst systems. Metallocene catalyst systems include a metallocene component and at least one activator. Desirably, these catalyst system components are supported on support materials, such as inorganic oxide or polymeric materials.

Metallocenes

As used herein "metallocene" and "metallocene component" refer generally to compounds represented by the formula $Cp_mMR_nX_q$ wherein Cp is a cyclopentadienyl ring which may be substituted, or derivative thereof which may be substituted, M is a Group 4, 5, or 6 transition metal, for example titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum and tungsten, R is a hydrocarbyl group or hydrocarboxy group having from one to 20 carbon atoms, X is a halogen, and m=1-3, n=0-3, q=0-3, and the sum of m+n+q is equal to the oxidation state of the transition metal.

Methods for making and using metallocenes are very well known in the art. For example, metallocenes are detailed in United States Patent Nos. 4,530,914; 4,542,199; 4,769,910; 4,808,561; 4,871,705; 4,933,403; 4,937,299; 5,017,714; 5,026,798; 5,057,475; 5,120,867; 5,278,119; 5,304,614; 5,324,800; 5,350,723; and 5,391,790 each fully incorporated herein by reference.

Methods for preparing metallocenes are fully described in the Journal of Organometallic Chem., volume 288, (1985), pages 63-67, and in EP-A- 320762, both of which are herein fully incorporated by reference.

Desirable metallocene catalyst components are described in detail in U.S. Patent Nos. 5,145,819; 5,243,001; 5,239,022; 5,329,033; 5,296,434; 5,276,208; 5,672,668; 5,304,614; 5,374,752; 5,240,217; and 5,643,847; and EP 549 900 and 576 970 all of which are herein fully incorporated by reference.

Additionally, metallocenes such as those described in U. S. Patent No. 5,510,502 (incorporated herein by reference) are suitable for use in this invention.

Activators

Metallocenes are generally used in combination with some form of activator. Alkylalumoxanes are desirably used as activators, most desirably methylalumoxane (MAO). There are a variety of methods for preparing alumoxane, non-limiting examples of which are described in U.S. Patent No. 4,665,208, 4,952,540, 5,091,352, 5,206,199, 5,204,419, 4,874,734, 4,924,018, 4,908,463, 4,968,827, 5,308,815, 5,329,032, 5,248,801, 5,235,081, 5,103,031 and EP-A-0 561 476, EP-B1-0 279 586, EP-A-0 594-218 and WO94/10180, each fully incorporated herein by reference. Activators will also include those comprising or capable of forming non-coordinating anions along with catalytically active metallocene cations. Compounds or complexes of fluoro aryl-substituted boron and aluminum are particularly suitable, see, e.g., US patents 5,198,401; 5,278,119; and 5,643,847.

Support Materials

The catalyst systems used in the process of this invention may optionally be supported using a porous particulate material, such as for example, talc, inorganic oxides, inorganic chlorides and resinous materials such as polyolefin or polymeric compounds.

The most preferred support materials are porous inorganic oxide materials, which include those from the Periodic Table of Elements of Groups 2, 3, 4, 5, 13 or 14 metal oxides. Silica, alumina, silica-alumina, and mixtures thereof are particularly preferred. Other inorganic oxides that may be employed either alone or in combination with the silica, alumina or silica-alumina are magnesia, titania, zirconia, and the like.

The supported catalyst system may be used directly in polymerization or the catalyst system may be prepolymerized using methods well known in the art.

For details regarding prepolymerization, see U. S. Patent Nos. 4,923,833; 4,921,825; and 5,643,847; and EP 279 863 and EP 354 893 (each fully incorporated herein by reference).

Incorporation of the Thermoplastic Polymer with the Ethylene Copolymer

The plasticized polypropylene thermoplastics may be formed by blending the thermoplastic polymer with the ethylene copolymer. For small quantities sufficient for laboratory examination and analysis, a mixer, such as a Brabender mixer, will be sufficient. For larger or commercial quantities, the liquid ethylene copolymer may be pumped directly into an extruder zone containing the melted thermoplastic polymer.

The plasticized polypropylene thermoplastics of this invention are compositions that can be effectively used in many if not all of the uses known for polypropylene compositions. These uses include, but are not limited to: hot melt adhesives; pressure sensitive adhesives (as an adhesive component, particularly when the polypropylene has low levels of crystallinity, e.g., amorphous polypropylene); films (whether extrusion coatings, cast or blown; such will exhibit improved heat sealing characteristics); sheets (such as by extrusion in single or multilayer sheets where at least one layer is a plasticized polypropylene thermoplastic composition of the invention); any of meltblown or spunbond fibers; and, as thermoplastic components in thermoformable thermoplastic olefin ("TPO") and thermoplastic elastomer ("TPE") blends where polypropylene has traditionally been demonstrated to be effective. In view of these many uses, with improved low temperature properties and increased workability, the plasticized polypropylene thermoplastics offer a suitable replacement in selected applications for plasticized polyvinyl chloride (PVC).

The following examples are presented to illustrate the foregoing discussion. All parts, proportions and percentages are by weight unless otherwise indicated. Although the examples may be directed to certain embodiments of the present invention, they are not to be viewed as limiting the invention in any specific respect.

Examples

Example 1

The glass transition temperatures measured by dynamic mechanical thermal analysis ("DMTA" - tan δ peak) for blends of plasticizer liquids and elastomeric polypropylene (ePP) and amorphous polypropylene (aPP) are listed in **Table 3**.

DMTA measurements were determined by placing approximately 0.8 grams of the sample in a Rheometrics 25mm vacuum mold. A plunger is inserted into the mold, using a 1" spacer to hold the plunger above the vacuum port. This assembly is placed in a Carver press. The sample chamber is evacuated for at least 5 min. at ambient temperature and then heated to 190°C and held at that temperature for 10 min. while still under vacuum. After this period, the press heater is turned off, the spacer removed, and 5,000 lbs. of pressure applied while a nitrogen purge is passed through the mold cooling port. Once the sample has cooled to room temperature, the plunger is pushed out of the mold using a press and the plunger removal tool. Cooling to lower temperature may be required for samples that cannot easily be removed from mold faces.

Using a 13mm wide bar cutter, the sample is cut to size (1 to 2mm x 13mm x 20mm) for DMTA test just prior to use. The Polymer Labs DMTA is calibrated for the A, B and C transducer stiffness settings. L frame and C sample clamps are used for mounting the sample. The test parameters include a single cantilever; peak to peak displacement of 64 microns (less for stiffer samples), frequency of 1 or 10 Hz, start temperature of -140°C, max temperature of 150°C. Temperature is increased at a rate of 3°C/min.

Tan δ is the ratio of E"/E' where E" is the loss modulus and E' is the elastic modulus or storage modulus.

These measurements clearly show a pronounced depression in the T_g of the polypropylene from ~273-276 °K. Also shown in Table 3 are calculated T_g's based on equation (2).

$$1/T_g = w_1/T_{g1} + w_2/T_{g2}$$

where w_1 is the weight fraction of component 1, T_{g1} is the glass transition temperature of component 1, w_2 is the weight fraction of component 2, and T_{g2} is the glass transition temperature of component 2 .

Table 3

Comparison of Measured (DMTA) and Calculated Tg of Plasticized Amorphous Polypropylenes

Blend		Tg Measured (°K)	Tg Calc[d] (°K)
a-PP (wt%)	*Copolymer (wt%)*		
e-PP[a] (60)	Copolymer 2 (40)	256	249
a-PP(50)[b]	Copolymer6[c] (50)	258	—
a-PP(50)	Copolymer 2 (50)	245	243
a-PP(50)	Copolymer 3 (50)	249	238
a-PP(50)	Copolymer 1 (50)	242	233

[a] Molecular weight characterization of this polymer (GPC-VIS): MN = 15k; MW = 302.5k; MZ = 762.6k, and crystallinity (~5% based on DSC). Prepared in accordance with the G.W. Coates and R. M. Waymouth paper appearing in "Science", vol. 267, p. 217 (1995) incorporated by reference herein.

[b] Amorphous polypropylene polymerized at 90°C for 40 min. using a mono(cyclopentadienyl)Ti(4+) catalyst activated with MAO (constant Al/Ti ratio) in hexane. This amorphous polypropylene contained between 4.9 and 6.3% 2,1 defect insertions by no 1,3 insertions and ~60% racemic triads and ~40% meso triads. GPC-VIS data MW ~ 274.1k; MWD = 2.3. The polymerization process is described in greater detail in U. S. Patent No. 5,420,217 which is incorporated by reference herein.

[c] high molecular weight (M_w = 274,000) ethylene octadecene ("OD") copolymer; 30 mole % OD

[d] Polypropylene Tg used in calculation eq(2) is 273°K.

Example 2

Density results for two blends of aPP (described in Example 1) with copolymers 1 and 2 are compared with the density of the unblended aPP are reported in Table 4. Density was measured using a density gradient column (ASTM D-792).

Table 4.
Density Comparison (23°C):
aPP versus Examples of Plasticized aPP

Copolymer	Copolymer Liquid, wt%	Density, g/cm3 @23°C
None	0	0.8525
Copolymer 1	50	0.8591
Copolymer 2	50	0.8592

The density measured for the unblended aPP is comparable to those reported for amorphous polypropylene in the literature. The increased density (0.007 g/cm) of the blends relative to the unblended aPP indicates a substantial reduction in "void volume". This reduction in void volume is suggestive of miscibility of the blends.

Example 3

Dynamic mechanical thermal analysis of the 50:50 blend of aPP (Example 1) + Copolymer 1 was measure, and the results illustrated in **Figure** 2. The peak in tan δ occurs at 245°K and is illustrated in **Figure** 3. This value is in good agreement with the Tg measured for this blend by DSC at a scan rate of 10 °C per minute (242°K). DMTA of this same aPP without plasticizer gives a peak at 276°K.

DMTA's were measured (not illustrated) for two other blends: ePP (Example 1) + Copolymer 3 and aPP (Example 1) + Copolymer 3. The Tg's measured from DMTA and DSC for these three blends are compared in **Table 5**. Agreement between the two methods is good.

Table 5.

Comparison of Tg Measured by DSC and DMTA

Blend		Tg, °K	
Thermoplastic Polymer (wt %)	Copolymer (wt %)	DSC	DMTA
e-PP [a] (60)	Copolymer 2 (40)	256	258
a-PP [a] (50)	Copolymer 2 (50)	245	247
a-PP [a] (50)	Copolymer 1 (50)	242	245

[a] The thermoplastic polymers described in Example 1.

In all three blend DMTA's, the tan δ peak was substantially broader than that for the pure aPP, and markedly skewed to higher temperature as well.

Figure 4 illustrates NMR relaxation measurements ($T_{1\rho H}$) for the blend of aPP and Copolymer 2

Procedure:

The NMR data were obtained on a Bruker DSX-500 spectrometer using a variable-temperature 4-mm MAS probe. Radio-frequency power levels were 70 kHz for spin-locking and decoupling, corresponding to a H π/2 pulse of 3.5 microseconds. Data were collected at MAS speeds of 4.5-5 kHz. Depending on the temperature, anywhere from 100 to 2,000 scans were collected per relaxation time increments. $T_{1\rho H}$ measurements were made using standard ^{13}C cross-polarization observations experiments, in which the length of the H spin-lock pulse was incrementally varied prior to cross-polarization. The blend was prepared in toluene solutions containing a BHT stabilizer, and dried under nitrogen at ambient temperature, with further drying at 50° C in vacuum for 48 hours.

NMR relaxation measurements also demonstrate miscibility between aPP and Copolymer 2 (50:50 wt:wt).

Example 4

Storage modulus depression data were measured by DMTA as described in Example 1.

Storage modulus depression can be achieved through manipulation of crystallinity of the polypropylene as well as addition of plasticizer. The plateau storage modulus of reactor grade aPP (Example 1) at ambient temperature is 0.47 Mpa, or just above 2x10 -6 dynes/cm (the "Dahlquist Criterion") for adhesion. Addition of low molecular weight ethylene copolymer plasticizer can depress the storage modulus at least another decade or so, or well below the Dahlquist Criterion, thus rendering the polymers exceptionally tacky. A new family of adhesives could be made based on these blends where first the crystallinity of the polypropylene is adjusted appropriately with a combination of tacticity defects and comonomer then miscible liquid added to adjust and optimize the balance of properties. Optionally, miscible tackifiers may also be used. Even with a melting point of 125°C -corresponding to a crystallinity of just ~15% and total defects of ~ 9-10 mole % - one would have a wide Tm - Tg use window on the order of 130-140°C.

Example 5

A summary of ambient temperature properties measured on tensile bars made from a blend of isotactic polypropylene (PD-4062 resin) and Copolymer 2 is provided in Table 6. PD-4062 resin is a polypropylene homopolymer available from Exxon Chemical. PD-4062 resin has a melt flow rate of 3.9 g/10min (ASTM D 1238) and a density of 0.90 g/cm^3 (ASTM D 792).

Tensile Measurement Procedure

Approximately 3 grams of sample is placed in a 2.5" x 2.5" x 6 mil mold template between two pieces of Teflon foil. This assembly is placed between the 6" x 6" platens of a Carver Press and heated to 190°C for 2 min. At this point the sample is compressed at 5,000 psi and 190°C for an additional 2 min. The mold is then removed, placed on cooling platens, and cooled to room temperature.

After the sample is removed from the mold, it is inspected for bubbles and imperfections. Tensile specimens are cut from areas having no visible imperfections using a standard micro "bog bone" cutter (5.5-6 mil thickness, 0.08" in width and 0.197 in length). Five samples were cut from each compression molded plaque. The samples were allowed to age at least 48 hours before tensile measurements were carried out.

Each tensile specimen was tested on the Instron 4502 using serrated grips set at 80 psi. The sample rate was 10 points per second at a crosshead speed of 2"/min.

Table 6.

Summary of Tensile Bar Data Recorded at Ambient Temperature for Blends of Copolymer 2 with isotactic polypropylene (PD4062)

Wt% Copolymer 2	Modulus (kpsi)	Stress@Yield (kpsi)	%Strain@Max Load	Energy-to-Break (lbs-in)
6	50.3	4.77	845	2.75
12.5	40.5	4.1	822	3.18
18	33.2	3.52	690	2.24

Example 6

A summary of ambient temperature properties measured on tensile bars made from a blend of isotactic polypropylene and Copolymer 3 is provided in Table 7.

Table 7.

Summary of Tensile Bar Data Recorded at Ambient Temperature for Blends of Copolymer 3 with isotactic polypropylene (PD4062)

Wt% Copolymer 3	Modulus (kpsi)	Stress @ Yield (kpsi)	%Strain-to-Brk	Energy-to-Break (lbs-in)
0	55.0	5.68	503	2.29
10	41.6	4.32	871	3.62
20	30.0	3.28	848	2.52

Example 7

Figure 5 illustrates the roughly linearly decreasing effect on Young's modulus of isotatic polypropylene by blending Copolymers 2 and 3 with isotactic polypropylene (PD4062). In keeping with the data shown in **Figure 4** (DMTA data), the Young's modulus obtained from the tensile bars decreases – roughly linearly - with increasing plasticizer content. In addition, the energy-to-break for the tensile bars increases over 50% due to addition of ~5-15 wt% plasticizer (maximum around 10 wt%) as illustrated in **Figure 6**).

Example 8

An examination of the large strain behavior/recovery of a very soft [ePP (described in Example 1) + Copolymer 2] 60:40 wt:wt blend was undertaken. A hysterisis series of tensile curves (AJ Peacock procedure) is shown in **Figure 7**.

Elastic recovery of this material is ~90% 24 hours after 1000% elongation. Elongation to break is ~1400%.

Hysterisis Test Procedure

The hysterisis tests were conducted on the Instron 1123D. The film hysteresis testing procedure used is an Exxon variation of a procedure described by DuPont in its brochure on its polyether urethane elastic product, T-722a. In the Exxon variation, 1x6 inch strips are subjected to successive % strains of 100, 200, 300, 400, 500 and 1,000% (jaw gap separation of 2" and crosshead speed of 20"/min). The sample is held for 30 seconds at extension and then retracted and held at 60 seconds a relaxation prior to the next extension cycle. Figure 8 illustrates the hysteresis stress/strain curve.

Tables 8, 9 and 10 provide mechanical properties data for several polypropylene liquid blends and comparative data for non-blended polypropylene. The mechanical data were generated using various tests that are listed in the first column of each Table. The procedures for conducting each such test are known and understood by one skilled in the art.

Table 8

	PD4062	PD4062 10% EB8D	PD4062 20% EB8D	Escorene 3445	Escorene 3445 10% EB8D	Escorene 3445 20% EB 8D	RCP PD9272	RCP PD9272 10% EB P-42-27
Gardner Impact RT (in-lbs)	220. (B) (DB)	249.8 (D)	222.7 (D)	109.3 (S) (DB)	188.0 (D) (S) (DB)	20.0 (DB)	311.3 (D)	230.9 (D)
Gardner Impact -29°C(in-lbs)	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8
Notched Impact RT (ft-lb/in)	0.578	0.895	1.159	0.356	0.518	0.388	1.312	1.551
Notched Impact -18°C (ft-lb/in)	0.269	0.178	0.257	0.206	0.219	0.136	0.183	0.279
Notched Impact -40°C (ft-lb/in)	0.181	0.215	0.189	0.206	0.156	0.144	0.153	0.199

Table 9

	PD4062	PD4062 10% EB8D	PD4062 20% EB8D	Escorene 3445	Escorene 3445 10% EB8D	Escorene 3445 20% EB8D	RCP	RCP 10% EB P-42-27
1% Secant Flex Mod (psi)	220873	133105	90491	172196	116355	72976	106957	71152
1% tangent Flex Mod (psi)	227616	140036	96440	175337	124411	78142	110312	74769
Flex Strength (psi)	2683	1575	1084	2070	1417	873	1290	859
Energy at peak (in-lb)	0.229	0.131	0.092	0.173	0.120	0.075	0.108	0.068

Table 10

	PD4062	PD4062 10% EB8D	PD4062 20% EB8D	Escorene 3445	Escorene 3445 10% EB8D	Escorene 3445 20% EB8D	RCP	RCP 10% EB P-42-27
Yield Stress (psi)	4922	3885	3045	4591	3569	2592	3316	2510
Elongation at Yield (%)	19.5	29.01	38.23	20.05	28.65	28.63	20.26	29.06
Elongation at Break (%)	349.79	998.02	998.84	357.08	558.36	55.53	998.40	998.21
Stress at Break (psi)	3164	3187	2998	1617	1490	2355	3067	2586
Youngs Modulus (psi)	85591	47669	26191	74097	43446	27465	44123	27310
Energy @ Break (in-lb)	1369	3506	3147	1162	1663	151	2878	2468

"B" means brittle, "S" means strings "DB" means ductile brittle and "D" means ductile.
PD4062 is a polypropylene homopolymer described in Example 5
Escorene 3445 is a polypropylene homopolymer available from Exxon Chemical. MFR 35 g/10 min (ASTM D1238) Density 0.90 g/cm^3 (ASTM D792)
RCP PD9272 is a polypropylene/ethylene random copolymer available from Exxon Chemical. MFR 2.9 g/10 min (ASTM D1238) Density 0.89 g/cm^3 (ASTM D792)
EB8D is a an ethylene(24 wt%) propylene (76 wt%) copolymer, 4000 Mn.
P 42-27 is an ethylene (51 wt%) butene (49 wt%) copolymer, 5184 Mn.

While the present invention has been described and illustrated by reference to particular embodiments, those of ordinary skill in the art will appreciate that the invention lends itself to many different variations not illustrated herein. For these reasons, then, reference should be made solely to the appended claims for purpose of determining the true scope of the present invention.

Although the appendant claims have single appendencies in accordance with U. S. patent practice, each of the features in any of the appendant claims can be combined with each of the features of other appendant claims of the independent claim.

We claim the following:

Claims:

1. A plasticized polypropylene thermoplastic composition comprising a blend of:

A) from 50 to 99.9 wt% of a thermoplastic polymer derived from polypropylene, optionally with one or more copolymerizable monomer selected from C_2-C_{10} α-olefin or diolefin, said polymer having a melt flow rate (MFR) (ASTM D1238) of from 0.3 to 1000 and a crystallinity by differential scanning calorimetry of from 0 to 70%;

B) from 0.1 to 50 wt % of at least one ethylene copolymer having a weight-average molecular weight (M_w) (GPC) of from 500 to 10,000, a molecular weight distribution (MWD) (GPC) of from greater than 1.5 to less than or equal to 3.5, and a comonomer content of from greater than or equal to 20 mol % to less than 70 mol %; and optionally,

C) from 0 to 20 wt% of a thermoplastic polypropylene modifier compound other than that of B).

2. The polypropylene thermoplastic composition of claim 1 wherein said ethylene copolymer has a glass transition temperature (T_g) of from greater than or equal to -80 °C to less than or equal to -30 °C.

3. The polypropylene thermoplastic composition of claim 1 wherein said ethylene copolymer has less than or equal 5% ethylene crystallinity by differential scanning calorimetry.

4. The polypropylene thermoplastic composition of claim 1 wherein said thermoplastic polymer A) has a crystallinity by DSC at a scan rate of 10 °C per minute of less than 60 % and the wt% of said ethylene copolymer is less than or

equal to y, wherein y is in the range of 0.1 to 50, as determined by y in the equation

$$y = 50 - 0.5x$$

where x = the % crystallinity of said thermoplastic polymer A).

5. The polypropylene thermoplastic composition of claim 1 wherein said thermoplastic polymer A) has a crystallinity by DSC at a scan rate of 10 °C per minute of greater than or equal to 60 % and the wt% of said ethylene copolymer is 20.

6. The polypropylene thermoplastic composition of claim 2 wherein said ethylene copolymer comprises, in addition to ethylene, one or more of C_3 to C_{20} linear or branched α-olefin or diolefin.

7. The polypropylene thermoplastic composition of claim 6 wherein said ethylene copolymer is an ethylene-butene copolymer, ethylene-hexene copolymer or ethylene-octene copolymer.

8. The polypropylene thermoplastic composition of claim 1 wherein said thermoplastic polypropylene modifier compound C) constitutes greater than 0.001 wt% of the total blend and is selected from one or more of the group consisting of antioxidants, fillers, pigments, hydrocarbon resins, rosins or rosin esters, waxes, UV stabilizers, and additional plasticizers.

9. A plasticized polypropylene thermoplastic composition comprising a blend of:

A) from 50 to 99.9 wt% of a thermoplastic polymer derived from amorphous polypropylene, optionally with one or more copolymerizable monomer selected from C_2-C_{10} α-olefin or diolefin, said thermoplastic polymer having a melt flow rate (MFR) (ASTM D1238) of from 0.5 to

1000 and a crystallinity by differential scanning calorimetry of from 0 to less than 5%;

B) from 0.1 to 50 wt% of at least one ethylene copolymer having a weight-average molecular weight (M_w) (GPC) of from 500 to 10,000, a molecular weight distribution (MWD) (GPC) of from greater than 1.5 to less than or equal to 3.5, and a comonomer content of from greater than or equal to 20 mol% to less than 70 mol%; and optionally,

C) from 0 to 20 wt% of a thermoplastic polypropylene modifier compound other than that of B).

10. The polypropylene thermoplastic composition of claim 9 wherein said ethylene copolymer has a glass transition temperature (T_g) of from greater than or equal to -80 °C to less than or equal to -30 °C.

11. The polypropylene thermoplastic composition of claim 9 wherein said ethylene copolymer has less than or equal 5% ethylene crystallinity by differential scanning calorimetry.

12. The polypropylene thermoplastic composition of claim 9 wherein said thermoplastic polymer A) has a crystallinity by DSC at a scan rate of 10 °C per minute of less than 5 % and the wt% of said ethylene copolymer is less than or equal to y, wherein y is in the range of 0.1 to 50, as determined by y in the equation

$$y = 50 - 0.5x$$

where x = the % crystallinity of said thermoplastic polymer A).

13. The polypropylene thermoplastic composition of claim 10 wherein said ethylene copolymer comprises, in addition to ethylene, one or more of C_3 to C_{20} linear or branched α-olefin or diolefin.

14. The polypropylene thermoplastic composition of claim 13 wherein said ethylene copolymer is an ethylene-butene copolymer, ethylene-hexene copolymer or ethylene-octene copolymer.

15. The polypropylene thermoplastic composition of claim 9 wherein said thermoplastic polypropylene modifier compound C) constitutes greater than 0.001 wt% of the total blend and is selected from one or more of the group consisting of antioxidants, fillers, pigments, hydrocarbon resins, rosins or rosin esters, waxes, UV stabilizers, and additional plasticizers.

16. A plasticized polypropylene thermoplastic composition comprising:
a blend of a thermoplastic polymer and an ethylene copolymer,
wherein the thermoplastic polymer derived from polypropylene, optionally with one or more copolymerizable monomer selected from C_2-C_{10} α-olefin or diolefin, said thermoplastic polymer having a melt flow rate (MFR) (ASTM D1238) of from 0.3 to 1000;
wherein the ethylene copolymer has a weight-average molecular weight (M_w) (GPC) of from 500 to 10,000, a molecular weight distribution (MWD) (GPC) of from greater than 1.5 to less than or equal to 3.5, and a comonomer content of from greater than or equal to 20 mol % to less than 70 mol %; and
wherein the wt % of said ethylene copolymer in the thermoplastic composition is less than or equal to y, wherein y is in the range of 0.1 to 50, as determined by y in the equation

$$y = 50 - 0.5x$$

where x = the % crystallinity of said thermoplastic polymer.

17. The plasticized polypropylene thermoplastic composition of claim 16 wherein said ethylene copolymer has a glass transition temperature (T_g) of from greater than or equal to -80 °C to less than or equal to -40 °C.

18. The plasticized polypropylene thermoplastic composition of claim 16 wherein said ethylene copolymer has less than or equal 5% ethylene crystallinity by differential scanning calorimetry.

19. The plasticized polypropylene thermoplastic composition of claim 16 wherein said ethylene copolymer comprises, in addition to ethylene, one or more of C_3 to C_{20} linear or branched α-olefin or diolefin.

20. The plasticized polypropylene thermoplastic composition of claim 16 wherein the thermoplastic polymer has a crystallinity by differential scanning calorimetry of from 0 to 70%.

Fig. 1

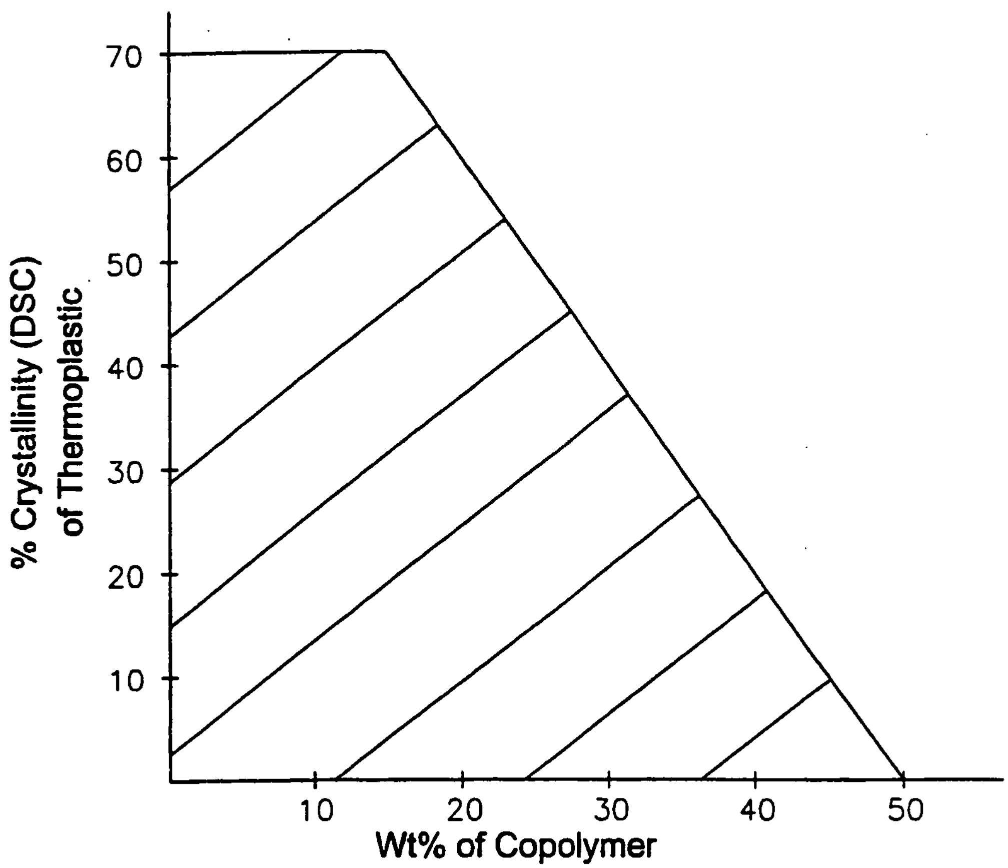

% Crystallinity (DSC) of Thermoplastic
70
60
50
40
30
20
10
10
20
30
40
50
Wt% of Copolymer

Fig. 2

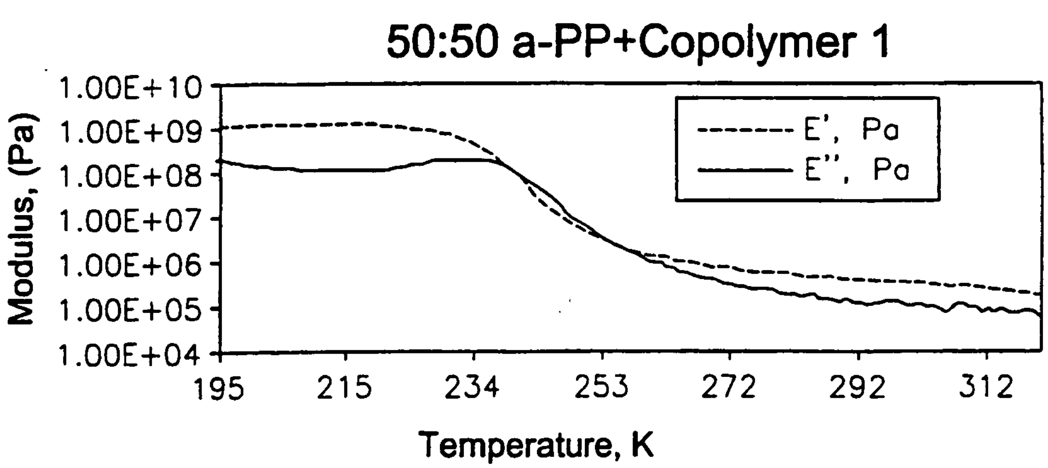

50:50 a-PP+Copolymer 1
Modulus, (Pa)
1.00E+10
1.00E+09
1.00E+08
1.00E+07
1.00E+06
1.00E+05
1.00E+04
E', Pa
E'', Pa
195
215
234
253
272
292
312
Temperature, K

Fig. 3

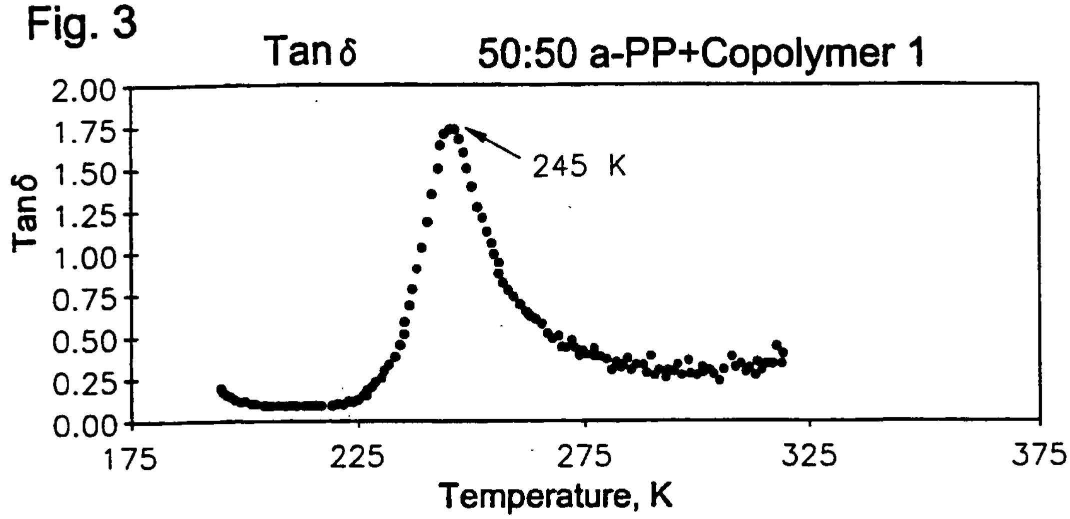


Fig. 5

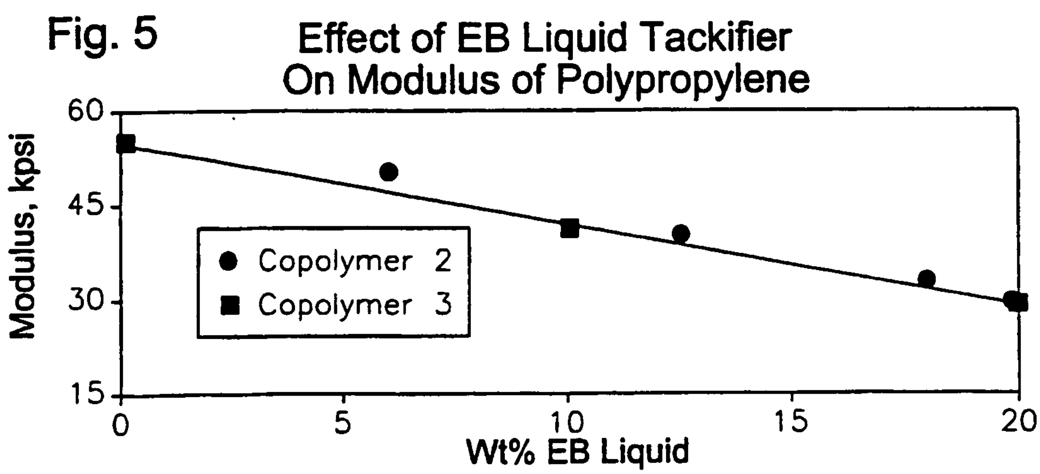


Fig. 6

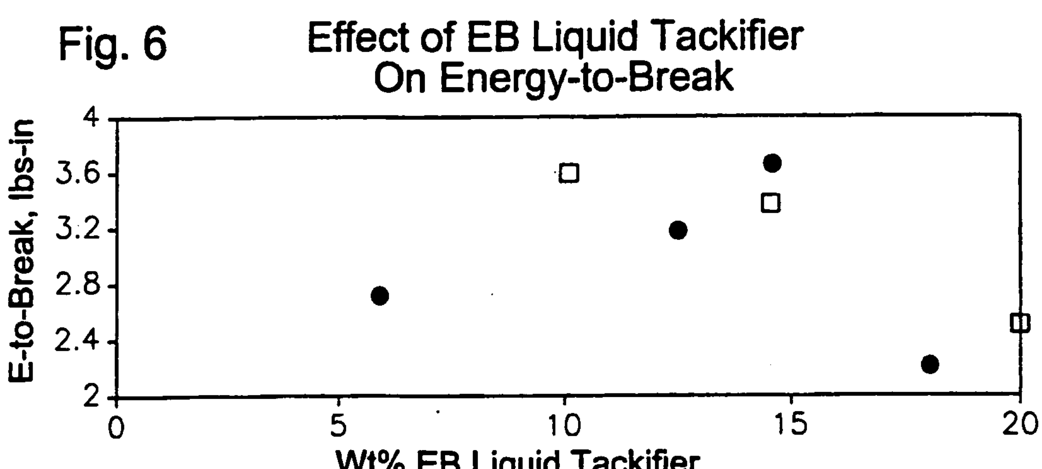


Fig. 4

The Influence of Low Molecular Weight Polyethylene-co-butene on a-PP T_{1pH} Relaxation

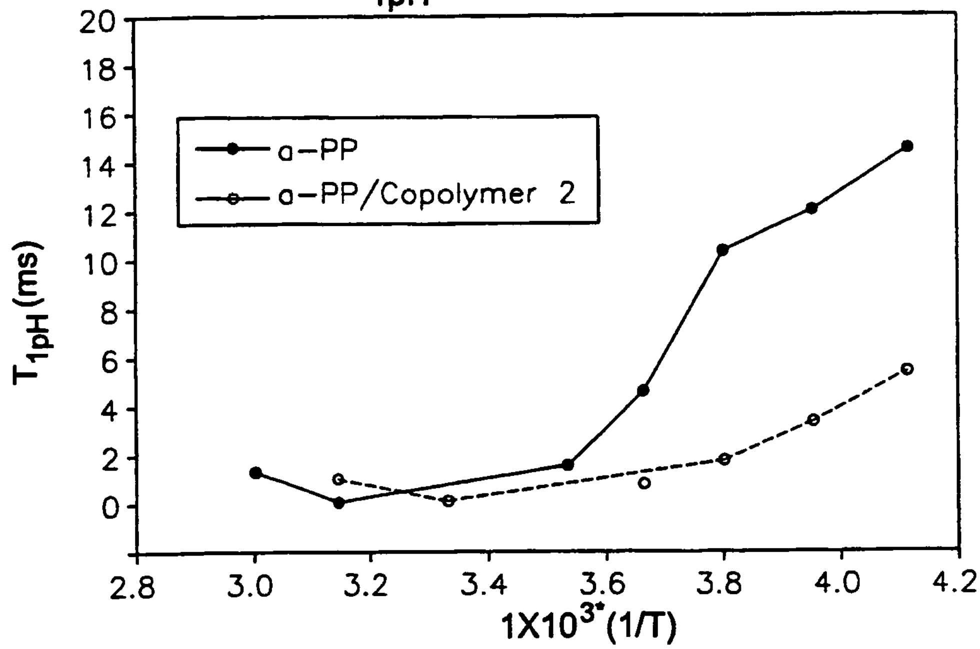
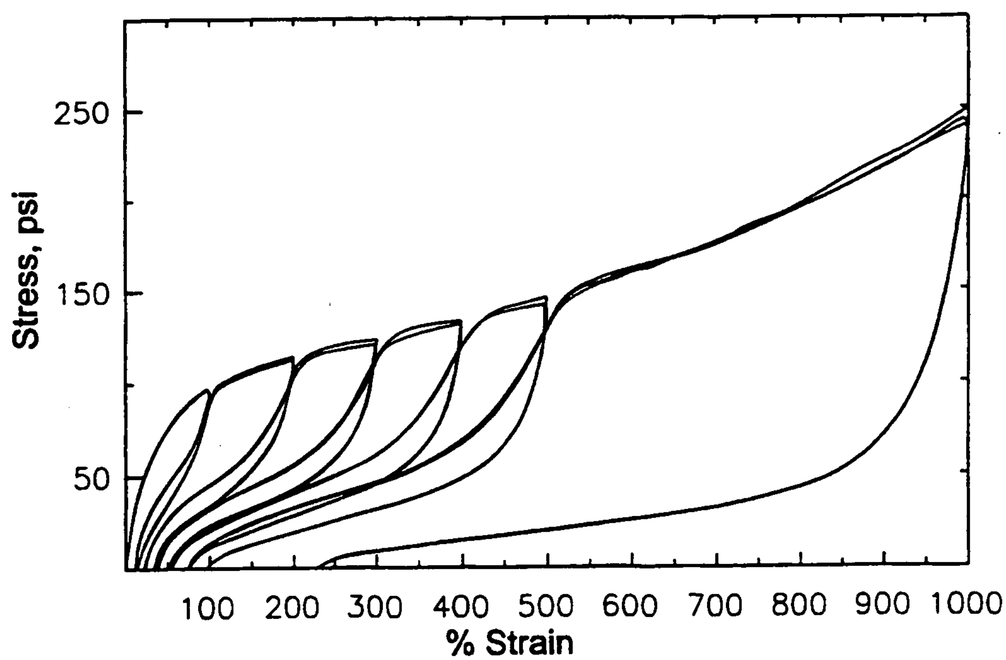


Fig. 7



INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 00/23940

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C08L23/10 C09J123/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C08L C09J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 814 127 A (MONTELL NORTH AMERICA INC) 29 December 1997 (1997-12-29)	1-20
Y	examples 1-4	1-20
Y	US 4 914 253 A (CHANG MAIN) 3 April 1990 (1990-04-03) column 1, line 58 - line 66	1-20
A	US 4 749 739 A (FOSTER BRUCE W ET AL) 7 June 1988 (1988-06-07) examples 1,3	1-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 January 2001	11/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schmidt, H

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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